Earthworks Institute Stormwater Harvesting Demonstration Project on the Arroyo Chamisos for the City of Santa Fe

by

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Executive Summary

For Earthworks Institute and the City of Santa Fe, Van and Steve designed 11 urban stormwater retrofits to demonstrate a variety of techniques geared toward modulating the flood pulse and cleaning pollutants out of the water before it enters the receiving arroyos. These sites are all on City lands and were chosen for cost effectiveness, distance from at-risk infrastructure, and easy access for public viewing. Custom designs for water harvesting earthworks were produced for each site, taking a balanced account of many variables. This report details four of the sites that best illustrate the variety of problems solved. All photos are by Van Clothier unless otherwise noted.

These projects were constructed by the Earthworks Institute youth crew, with oversight and training from the project designers. Two sites required excavation with a backhoe to create shallow basins and swales. These were finished with hand labor. The other sites were treated exclusively with hand labor, including planting with native vegetation, and watering to insure survival. Interpretive signage was installed to educate the public about the benefits of this water harvesting strategy. Earthworks Institute has solicited neighborhood "adopt an arroyo" volunteers to monitor and maintain these sites.

Urban Watershed Reconnaissance

The selected sites are on both sides of Arroyo Chamisos, where neighborhood street runoff is delivered to the arroyo via culverts and concrete conveyance channels. After initial site visits, we looked at satellite photos of these neighborhoods and took a few measurements to get a good approximation of the percent of the area that is impervious to rainfall infiltration. Streets, sidewalks, driveways and rooftops represent close to 70% of the surface area of these urban sub-watersheds.

The next step was to measure the watershed area that drains to each culvert. To do this we patrolled the streets with a GPS and a builder's level looking for watershed divides. Most of the streets are crowned with a concrete gutter on each side. Each road junction was carefully examined to determine which way the gutters flowed, by using the level and by analyzing the flow tracks of leaves and other debris left by the most recent runoff event. In several places the micro-topography of the streets and gutters at intersections suggested that water would flow several ways during a runoff event. The best way to determine the watershed area in this case would be to walk the streets in the rain, which we were able to do for several sub-watersheds.

Design Runoff Calculations
Upon returning to the office, we put the GPS watershed divide points in a GIS map and calculated the area of each urban sub-watershed. The next step was to estimate the target temporary storage volume for water quality and channel protection from flooding. Since these two parameters are usually close to the same volume, we used the channel protection volume equation below:

$$V_t = P/12 * IC/100 * A * .6$$

Where:
- V_t = Target Storage Volume (acre feet)
- P = 1-Year 24-hour storm depth (inches)
- 12 = Conversion factor (inches to feet)
- IC = Impervious Cover (%)
- A = Drainage area (acres)
- 0.6 = Pond routing factor

The above equation is from <u>Urban Stormwater Retrofit Practices</u>, by the Center for Watershed Protection.

The sites were then revisited to complete the designs. There were several limitations to the total detention volume for some sites: the size of basins that can be reasonably dug by hand, available area at each site for detention basins, slope, and areas to put the soil from the basins. Taking all of this into account, several sites will have less detention storage than the calculated target, yet considerably more than the present situation affords. The water harvesting from these sub-watersheds can still be improved by doing water harvesting curb cuts and other measures before the storm water runs down the culvert and out of town in the arroyo.

Project Reach -West Half

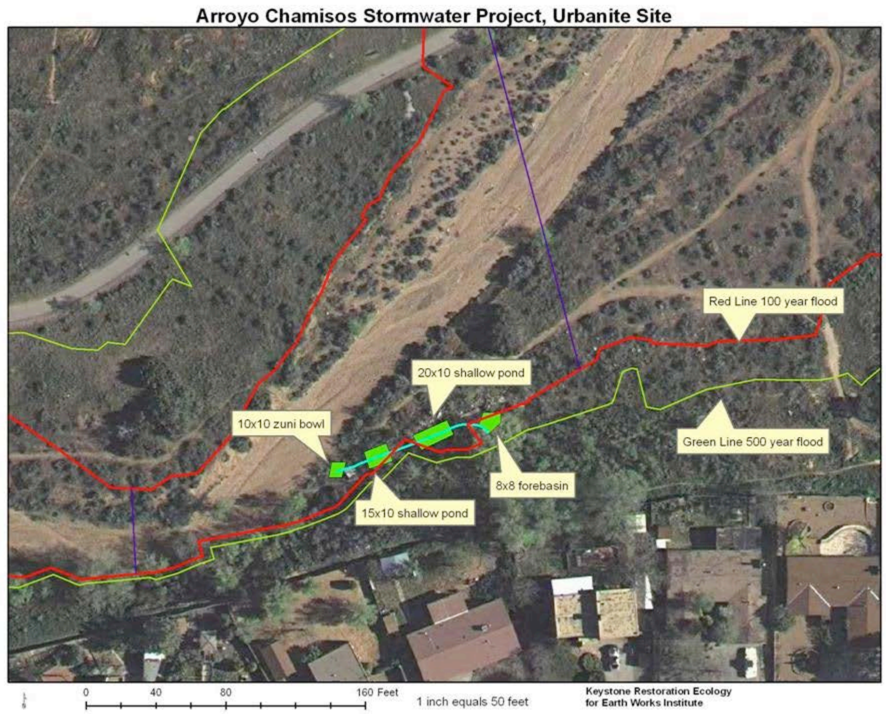
Project Reach - East Half

Urbanite Site **Urban sub-watershed area: 3 acres**
This site is named for the large amount of broken pieces of concrete (urbanite) littering the immediate vicinity. Urbanite is a good substitute for stone building material, being free and locally available. Stormwater arrives in a one foot diameter concrete culvert and proceeds through a narrow 1-3 foot deep gully for 93 feet to the arroyo. Some well meaning individual had built up a berm out of urbanite right at the end of the culvert, which may have caused the culvert to plug one day.

The treatment was to remove the blockage in front of the culvert and dig a fore-basin here instead. This will serve to dissipate energy, and also function as a sediment and trash trap. The long swale was broken into a series of ponds, using large chunks of urbanite to control the grade. A sledgehammer was used to custom cut the large unmovable chunks into manageable pieces for use in building pour-overs for the interconnected ponds. Upstream of each grade control, the swale was widened with hand shovel work, placing the material upstream of the grade control structures. The fill was compacted and then topped with cobble sized urbanite stones to provide surface protection.

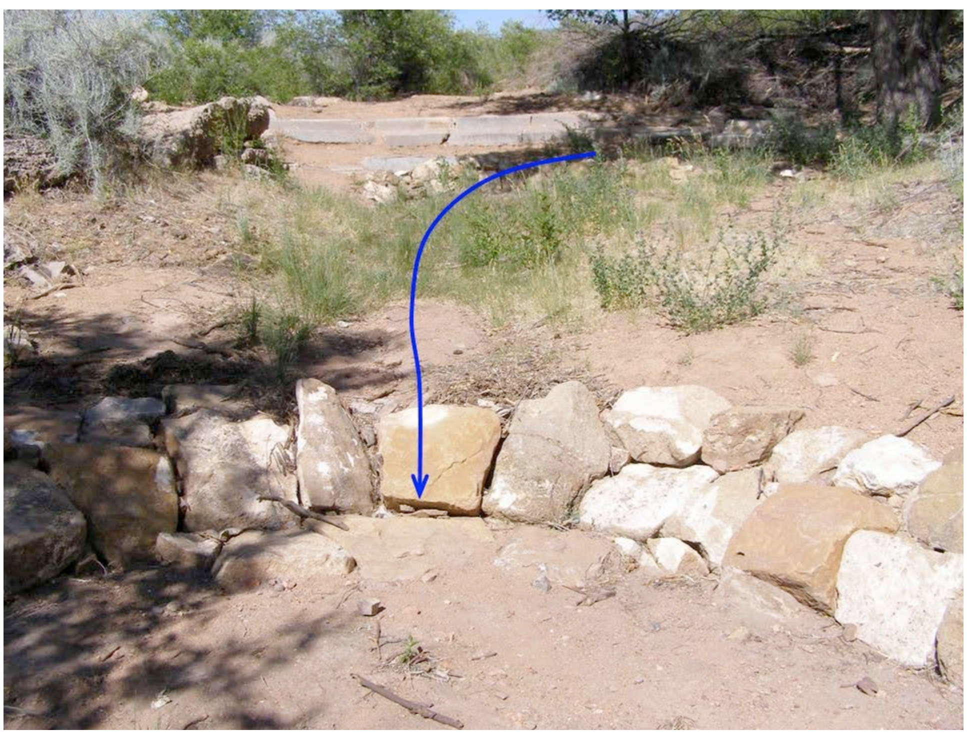
This design greatly increased the storm surge volume of the swale by deepening and widening it, and converting it to a series of shallow basins. The tail end of the swale has a constructed Zuni Bowl (rock lined water harvesting basin) which overflows over the vegetated bank of the Arroyo Chamisos. The swale portions between the shallow ponds were sloped at between 2-4%.

Urbanite site, showing culvert outlet and fore-basin. Photo by Kina Murphy.



Urbanite site, showing culvert outlet and fore-basin. Photo by Kina Murphy.

Urbanite was arranged to create an outdoor seating area adjacent to the basin, converting a brown fields area to a pocket park for the community.

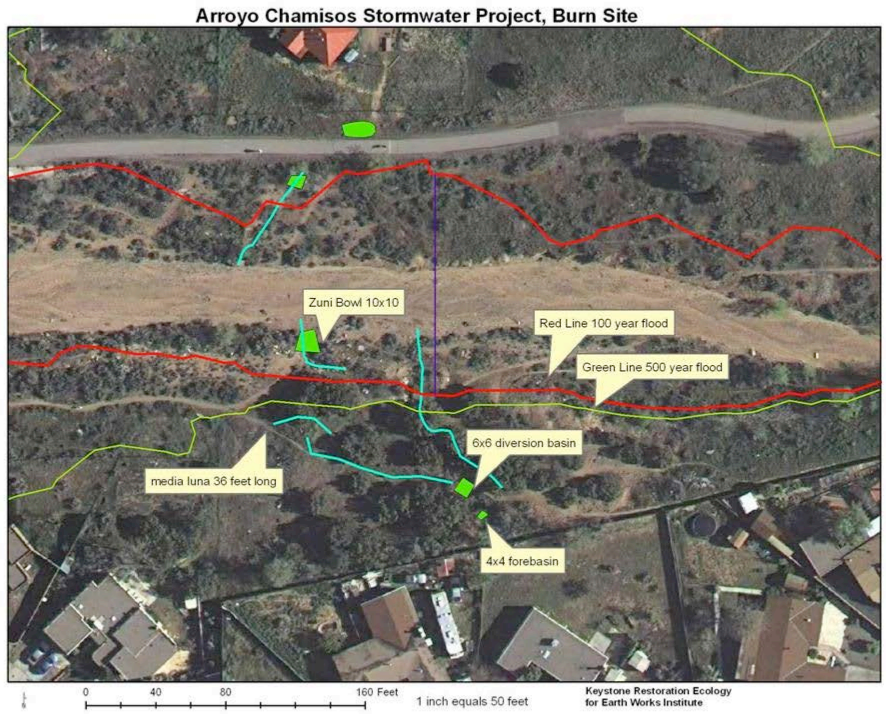


Looking upstream. Overflow from fore-basin goes through two sequences of swale and basin before it is released to the Arroyo Chamisos.

Last chance to harvest water before the arroyo: Overflow from Urbanite site must fill a Zuni Bowl with a very porous sand bottom and flow over the bank of Arroyo Chamisos to enter the arroyo as surface flow. While this is happening, the arroyo itself will be flowing at bankfull, so the confluence will not have an erosive drop off.

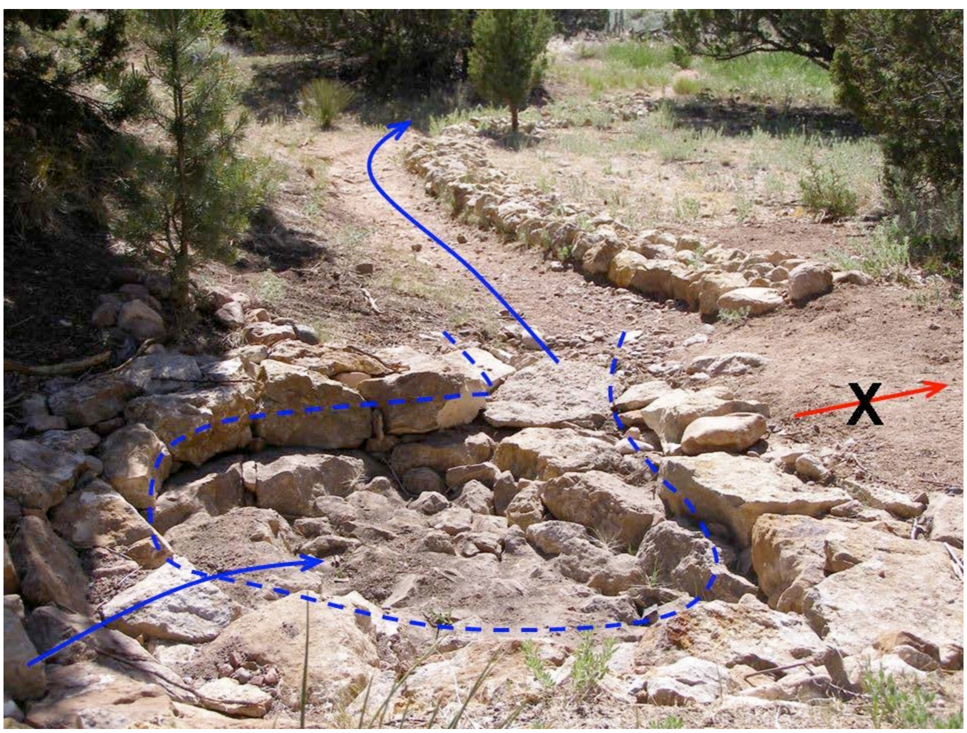
Burn Site Urban sub-watershed area: 1 acre

Before treatment, stormwater from this sub-watershed arrived as open channel flow and went down a steep, incised, and eroding channel for 116 feet, going straight down slope, and over several headcutting terrace drops on its way to the arroyo. It looks like a neighborhood resident had built some one rock dams in the channel above the drop offs, raising the grade. High flows could jump the channel and go down an overflow channel that heads diagonally down the high terrace and fans out in the vicinity of a recent burn where junipers were killed by a fire. This area has abundant plant growth, including a thicket of Golden Currant, *Ribes aureum*. This suggested an easy way to optimize water harvesting at this site: to direct <u>all</u> of the flow towards the burn site, where the vegetation is very thick, and the permeability is very high.



Burn site. Digging the fore-basin.

Completed fore-basin



The next basin is this Diversion Basin. The gully down the steep bank is blocked, and water now takes a longer, wider, flatter path. Large flows can overbank the curved stone channel bank to the right of the blue arrow and irrigate the land in the upper right of the photo. Base flows continue down channel to Media Luna.

Immediately after construction, showing a rock Media Luna
(Spanish for half moon).
It is a cobble mulch placed on contour to maximize the spreading of water.

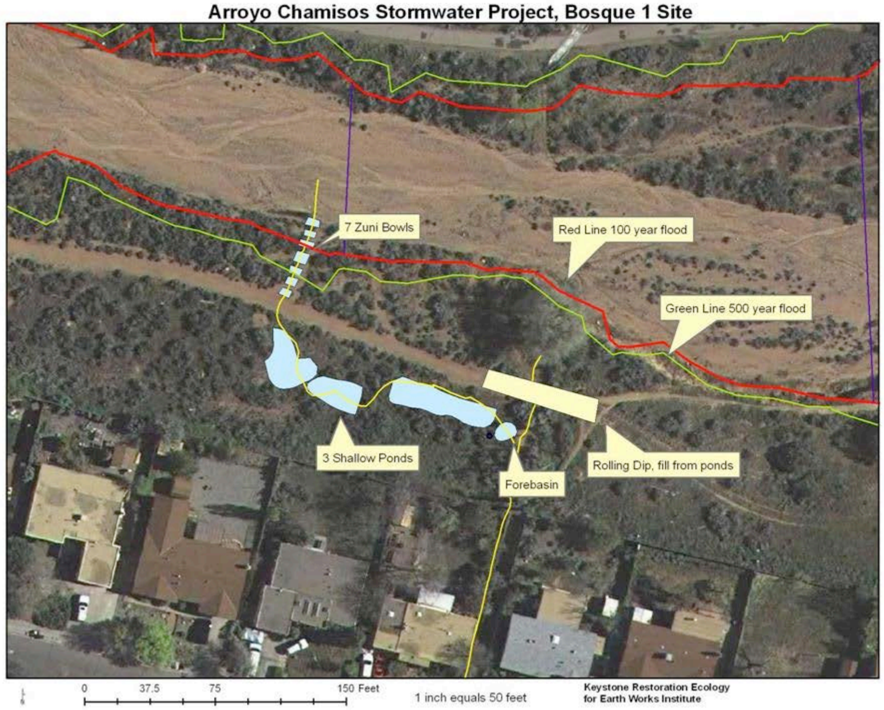
Burn site after several runoff events. Note increased vigor of grass.

Since there is very little sediment in this impermeable urban sub-watershed, and our swales will quickly become well vegetated, we didn't have to design a system to route sediment. This is true for all of the sites in this pilot project. The small amount of sediment that will arrive from the culvert over time will be sequestered in an alluvial fan created by the Media Luna at the Burn site.

Bosque Site #1 Urban Sub-watershed area: 5 acres

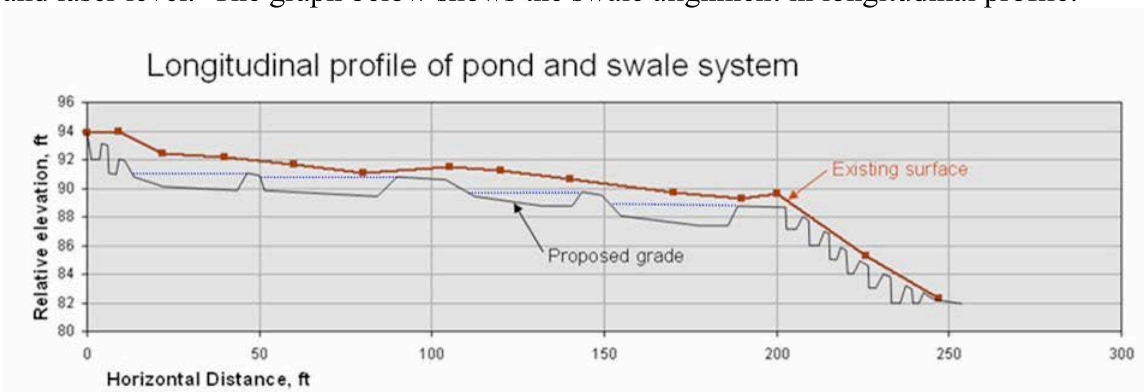
Stormwater from this five acre urban sub-watershed went down an open asphalt channel, then a shallow gully before dropping over the edge of an 8 foot terrace cut bank into the arroyo where it was eroding at the base of a large Siberian elm. This open channel was diverted by the project down a wide swath on the high terrace of the Arroyo Chamisos to a series of ponds and swales before being stepped down over the edge of the terrace to the receiving arroyo with a series of rock lined step pools.

Arroyo Chamisos Stormwater Project, Bosque 1 Site



This site features a diversion berm that directs storm water along a new flow path. The first basin is a small cleanable fore-basin to collect any sediment and trash prior to entering the system of ponds and swales. Stormwater then flows into a two pool step-pool system to drop the grade of the channel to the elevation of the terrace. Thereafter, three long shallow ponds snake along the terrace for 150 feet, separated by short stone and earth swales that keep the water level in the ponds at the desired depth during a runoff event One pond is kidney shaped, and the layout goes around large beautiful Chamisa bushes, etc. in order to preserve the existing vegetation as much as possible.

At the end of the water harvesting earthworks on the terrace, there is a designed low water crossing for the emergency fire road which runs along the edge of the terrace, then a series of seven step pools to dissipate energy as the overflow is dropped 8 feet down to the left bank of Arroyo de los Chamisos. The ponds and swales were dug with a backhoe, and the finish smoothing and rock work was done by human labor. During construction, many plants were saved and replanted around the new basins. The spoils from digging the ponds were used to fill in the old gully, build the diversion berm, and eliminate a troublesome dip in the fire road at this juncture. All disturbed areas were raked, seeded, mulched and planted with native xeriscaping. The project budget included providing irrigation for all the plantings to insure survival and rapid growth so that the site will quickly achieve full demonstration potential. This site was surveyed with a GPS and laser level. The graph below shows the swale alignment in longitudinal profile:

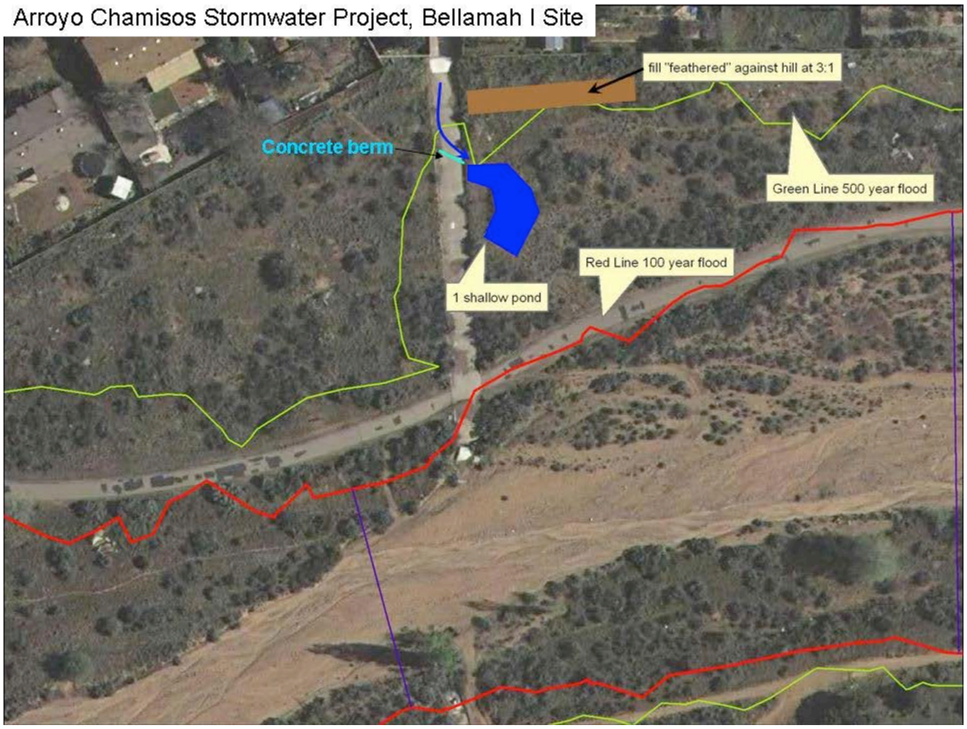


Bosque site #1 Longitudinal profile of original surface in red, with new grades for the stormwater basin and swale system in grey.

Bosque site 1, two days after construction.
Everything worked out pretty well, including the rainbow!

Bellamah Site #1 Urban Sub-watershed area: 2.5 acres

Stormwater from a 2.5 acre urban sub-watershed went down a 12 foot wide concrete channel and poured over the brink of this channel into the arroyo. This site was ideal for an oxbow basin, with a very flat non-vegetated area adjacent to the concrete channel.



The basin was designed with a shoreline that is higher than the curb of the channel. This was easy because the ground level around the concrete channel was ½ foot higher than the curb of the channel. Because of this, no water could ever leave the pond except through the inlet. A curb cut was made to let water into the oxbow basin. Still, a diversion berm was needed to shunt the water towards the inlet. Originally envisioned as a concrete berm, this was made more easily by bolting a low (2") plastic speed bump to the concrete, aligned diagonally across the wide concrete channel. This insures that sufficient stormwater will flow into the oxbow basin without significantly decreasing the existing channel capacity.

Stormwater first fills the basin, then bypasses the basin and continues along the originally designed stormwater system. This oxbow design feature could be used in yards in the city as well, as no outlet is needed and the system is very simple. The first flush of pollutants in the watershed will always be caught in the pond, and clean water will flow past into the channel of the arroyo. During a runoff event, the basin will be continuously topped off to maximize water harvesting volume.

A backhoe was used to dig this basin. The finishing work and planting will be done by hand. The backhoe entered off Bellamah Street, and drove down the 12 foot wide channel between two houses. The dirt from the pond was placed against the toe of a steep hill behind a house. This was banked to a 4:1 slope (much less steep than before), raked and seeded with native grass seed.

Mapping the urban sub-watershed.

Flat bottom concrete drainage channel was originally designed to send any storm water quickly to Arroyo Chamisos.

After oxbow basin was excavated, but before curb was cut.

Plastic speed bump was bolted to the drainage channel diagonally to capture all of the base flow, yet allow peak flow to bypass the diversion. Photo by Steve Vrooman.

Look at all this fabulous water! Basin is very sandy and has a high percolation rate. All the water from the monsoon storms soaked into the ground within 24 hours. This site still needs to have trees planted. Photo by Steve Vrooman.